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# Improved Cryogenic Coring Device for Sampling Wetland Soils

Cryogenic soil-coring methods (i.e., freezing the soil in situ with liquid nitrogen) have been used to collect shallow (≤ 50 cm) cores of loose, unconsolidated wetland sediments and offer several advantages over conventional soil-coring techniques. Freezing the soil eliminates compaction, dewatering, and loss of flocculent material at the water–sediment interface. Hence, cryogenic coring is suitable for sampling both shallow water bottoms and emergent marsh soils, although it has been primarily used for the latter. Because soil compaction is avoided, small diameter cores (3–5 cm) can be taken with minimal disruption to the marsh surface. The frozen soil core allows an investigator to immediately determine core quality, to measure soil profiles, and to subsample for further analysis. Processing the core in the field allows the collection of a complete and timely data set. Traditional core collection methods require inspection in the laboratory to determine these values.

We have used cryogenic coring in coastal Louisiana since 1986 to collect marsh soil cores for estimating vertical accretion from artificial soil marker horizons (e.g., feldspar [visible horizon] and stable isotopes [invisible horizon]) and soil bulk density. The cryogenic apparatus provides many advantages for determining soil bulk density because (1) the soil pore spaces are preserved as ice, (2) flocculent material is captured in ice, (3) compaction is insignificant, (4) microstratigraphy is preserved, and (5) surface area disruption is reduced.

## How Cryogenic Coring Works

Cryogenic coring uses liquid nitrogen to freeze the marsh substrate. The coring apparatus has three basic components: (1) a dewar to transport the liquid nitrogen to the field, (2) a coring device—a narrow copper tube referred to as a bullet, and (3) a system for efficiently delivering the liquid nitrogen from the dewar to the coring device (e.g., tygon tubing or a flexible stainless steel hose with welded connections). To collect a core, a 1 cm-diameter copper tube (bullet) is inserted in the marsh substrate to a desired depth and liquid nitrogen is pumped through it. The marsh freezes, beginning at the copper tube and moving outward, and the final core diameter is determined by how long the liquid nitrogen is pumped through the bullet. The bullet is pulled from the marsh substrate, resulting in "marsh-on-a-stick" or a "marsh-cicle." The depth of a visible marker horizon can be easily determined in the field from this frozen core. A conventional core tube can also be used to core through the frozen marsh before the bullet is extracted if a core of known volume is needed (e.g., to determine soil bulk density).

## Early Designs of the Apparatus

Designing an efficient coring apparatus requires balancing portability and efficient delivery of the liquid nitrogen. Pressure is required to deliver the

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liquid nitrogen from the dewar to the bullet. A large dewar (≥ 35 L) is naturally self-pressurizing but, when full of liquid nitrogen, is heavy and difficult for even two people to transport across the marsh. A small dewar (e.g., 10 L) can be carried across the marsh by a single person but requires a separate tank of gaseous nitrogen to drive the liquid nitrogen. Therefore, the apparatus is bulky and more easily transported by two people than one person. Furthermore, small dewars usually do not have built-in regulators. The custom-made regulators we have used, which are designed to be inserted into the neck of the dewar, have not been as efficient as the built-in ones available on larger dewars. A coring apparatus with a 35-L dewar was designed by R. M. Knaus in 1986 (Journal of Sedimentary Petrology 56: 551–553) and revised by 1990 to utilize a 10-L dewar with separate gas tank (R. M. Knaus and D. R. Cahoon, Journal of Sedimentary Petrology 60: 622–623).

## Design Improvements

We developed a new design of the coring apparatus that was originally developed and revised by R. M. Knaus. The new apparatus has a self-pressurizing 25-L dewar with a built-in regulator and is less bulky than the 10-L apparatus because no external gas tank is required. The delivery system is a flexible stainless-steel hose with screw fittings at both ends (in place of the tygon tubing or steel hose with welded connections, which often break). The new system allows more efficient pumping of liquid nitrogen, thereby decreasing the time to freeze the sediment and conserving liquid nitrogen. This apparatus still requires two people for transport across the marsh, but the increase in capacity combined with the more efficient delivery mechanism decreases the need to refill the unit. Field time is reduced with the 25-L apparatus.

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